Travel Management
Tonto National Forest
Final Climate Change Report

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Table of Contents

Introduction

Anticipated changes in the global climate over the coming decades could alter weather patterns resulting in higher temperatures, more intense droughts, worsening air quality and greater demand for forest resources. By the end of this century, temperatures are expected to rise approximately five to eight degrees Fahrenheit with the greatest warming to occur during the winter season (IPCC, 2015). This warming trend may lead to shorter winters and a longer season for summer activities (Joyce et al., 2001).

Rising temperatures may also lead to higher ground-level ozone concentrations. Ozone forms more readily under high temperatures and in the presence of nitrogen oxides, which may be emitted to the atmosphere in larger amounts as demand for electricity increases, in part from higher demand for air conditioning. More intense droughts may lead to more fugitive dust from areas where off-highway vehicle (OHV) use is in high demand. As the climate changes, so does the demand for forest resources. Therefore, maintaining forest roadways and managing the use of OHVs has become an important priority.

Current scientific consensus is that climate change is caused by a buildup of atmospheric greenhouse gasses, and that those greenhouse gasses modify the atmosphere's thermal radiative effect on surface temperatures. A review of current literature reveals average global temperatures are expected to increase by 0.5 degrees Fahrenheit to 8.6 degrees Fahrenheit by 2100 and by at least twice as much in the next 100 years as it has during the last 100 years (EPA, 2015). Climate models project an increase in the number of days with maximum temperatures above 90 degrees Fahrenheit for the United States, while precipitation rates will decline by five percent for much of Arizona and as much as ten percent for Arizona's southern half.

Climate modelers generally agree that the Southwestern United States is experiencing a drying tend that will continue into the latter part of 21st century. Some potential ecological implications of climate change trends in the Southwestern United States include (U.S. Forest Service, 2010):

- More extreme disturbance events, including wildfires and intense rain and flashfloods and wind events (Swetnam *et al.*, 1999).
- Greater vulnerability to invasive species, including insects, plants, fungi, and vertebrates (Joyce *et al*., 2007).
- Long-term shifts in vegetation patterns (Westerling *et al*., 2006; Millar *et al*., 2007).
- Cold-tolerant vegetation moving upslope, or disappearing in some areas. Migration of some tree species to the more northern portions of their existing range (Clark, 1998).
- Potential decreases in overall forest productivity due to reduced precipitation (USDA Forest Service 2005).

- Shifts in the timing of snowmelt (already observed) in the American West, which, along with increases in summer temperatures, have serious implications for the survival of fish species, and may challenge efforts to reintroduce species into their historic range (Joyce *et al*. 2007, Millar *et al*. 2007).
- Effects on biodiversity, pressure on wildlife populations, distribution, viability, and migration patterns, because of increasing temperatures, water shortages, and changing ecological conditions.

Affected Environment

Current conditions and trends in greenhouse gas emissions

Transportation-related emissions from cars, trucks, trains, ships, airplanes, and other vehicles are a major source of both regional air pollution and global climate change. Greenhouse gas emissions from transportation sources, resulting from the combustion of petroleum-based products like gasoline in internal combustion engines, are emitted in the form of carbon dioxide (CO_2), water vapor, methane (CH_4) and nitrous oxide (N_2O). In 2013, greenhouse gas emissions from transportation accounted for about 27 percent of total U.S. greenhouse gas emissions, making it the second largest contributor of U.S. greenhouse gas emissions after energy production.

Passenger cars and light-duty trucks are the largest sources of transportation-related greenhouse gas emissions in the U.S. and account for over half of the emissions from all mobile sources. The remainder of greenhouse gas emissions comes from other transportation modes such as commercial aircraft, shipping and trains. In 2011, the non-road sector, which is a broad subset of transportation sources that includes recreational off-highway vehicles, contributed approximately one percent of total U.S. emissions of CO_2 and have declined by approximately 25.9 percent between 1990 and 2013. The following is a list of equipment categories for the non-road sector[1]:

[1] Recreational equipment include snowmobiles, dirt bikes, and ATVs (EPA Non-road Engine and Vehicle Emission Study, 1991).

- Lawn and Garden Equipment
- Industrial Equipment
- Airport Service Equipment
- Construction Equipment
- Recreational Equipment
- Agricultural Equipment
- Recreational Marine Equipment
- Logging Equipment
- Light Commercial Equipment
- Commercial Marine Vessels

Off-highway vehicles are a subset of Recreational Equipment, which includes snowmobiles, dirt bikes, and ATVs. Figure 1 shows the yearly U.S. greenhouse gas emissions from the non-road transportation sector from 1990 to 2013[2].

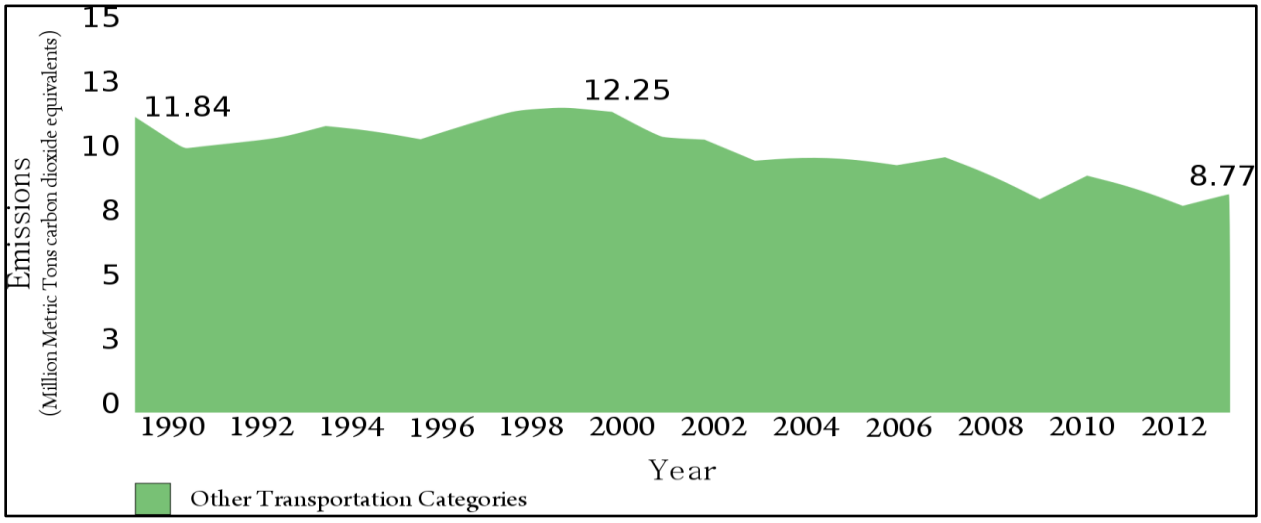

Figure 1: U.S. Greenhouse Gas Emissions, Non-Road Transportation Sector 1990-2013

In Arizona, the majority of carbon dioxide (CO_2) and nitrous oxide (N_2O) emissions come from mobile on-road sources such as passenger vehicles. The non-road sector accounted for approximately two percent of the total CO_2 emissions in 2011, while wildfires and prescribed fires were responsible for approximately 92 percent of all methane emissions during the same year. See Figure 2 for percent contributions of greenhouse gasses in Arizona for 2011.

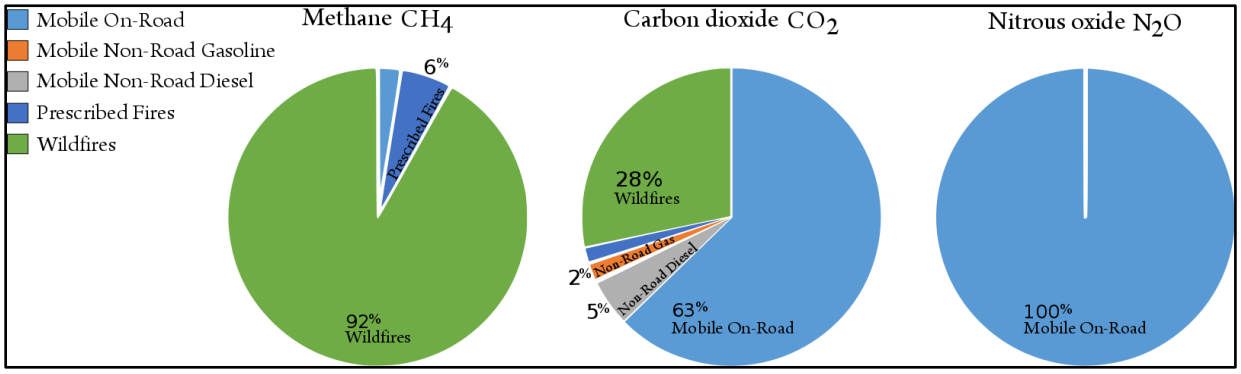

Figure 2: 2011 Arizona Greenhouse Gas Emissions by Sector

[2] Mobile Non-Road sector includes snowmobiles, dirt bikes, and ATVs (www3.epa.gov/climatechange/ghgemissions/inventoryexplorer/#transportation/allgas/source/all)

Environmental Effects

The Southwestern Regional Office planning program has summarized some ecological and socioeconomic effects of climate change (U.S. Forest Service, 2010). This document suggests the state of knowledge needed to address climate change at the forest scale is still evolving. Most global climate models are not yet suitable to apply to land management at the forest scale. This limits regional analysis of potential effects especially for a specific project.

Assumptions and Methodology

The following analysis presents the effects of climate change on air quality and public health, including current regulatory and environmental conditions, relevant to travel management planning on the Tonto National Forest. The four alternatives are evaluated based on their potential to contribute to increased air pollution under projected climate change conditions.

Current National Greenhouse Gas Regulations

On December 7th 2009, EPA determined that emissions from motor vehicles cause and contribute to the climate change problem and issued an Endangerment Finding under the Clean Air Act that carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) greenhouse gasses[3] constitute air pollution which threatens public health and welfare of current and future generations.

Key elements of EPA's Endangerment Finding include evidence of public health threats from increases in intensity or frequency of extreme weather, including severe heat waves, which can cause respiratory health problems ranging from decreased lung function and aggravated asthma to increased emergency department visits, hospital admissions, and even premature death. It also states that vulnerable populations may be especially vulnerable to climate impacts, including the poor and elderly populations.

On November 12, 2014, President Obama announced that by 2025 the United States intends to reduce greenhouse gas (GHG) emissions by 26 to 28 percent below 2005 levels. This economy-wide commitment comprises the U.S. contribution to the global effort to address climate change and will form a cornerstone of a new post-2020 international climate agreement. The USDA Climate Change Mitigation Strategy is a response to this commitment (USFS, 2015).

Current Greenhouse Gas Regulations Relevant To Travel Management

Arizona law prohibits state agencies from regulating greenhouse gas emissions. Arizona Revised Statutes ARS 49-191 states that a state agency shall not adopt or enforce a state or regional program to regulate the emission of greenhouse gas for the purposes of addressing changes in atmospheric temperature without express legislative authorization. On the other hand, federal agencies responsible for natural resource management are mandated to consider climate change in planning and projects, which has

[3] EPA also included hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6), however these pollutants are related to air conditioning units and are not emitted by ATVs or off-highway motorcycles.

resulted in net offset of approximately seventeen percent of U.S. fossil fuel emissions since 1990 (U.S. EPA/ OAP 2013).

General Effects of Climate Change

This section outlines the anticipated effects to forest environment and human health from exposure to increased air pollution under projected climate change conditions.

Anticipated Effects from Increased Air Pollution and Warmer Climate

The cause and effect of higher temperatures and a dryer climate are summarized in Table 1.

Table 1: Cause and Effect of Higher Temperatures and Dryer Climate

Climate change may cause:	**Resulting in:**
Higher temperatures	Increased demand for forest resources at higher elevations and higher ambient ozone concentrations.
Dryer climate	Increased chance for wild fires and higher ambient PM_{10} concentrations

Higher Ambient Temperatures Related to Forest Resources

Anticipated changes in the global climate over the coming decades could reshape off-highway vehicle use for the Tonto National Forest and, thus, alter air quality linked to PM_{10} and NO_x emissions. Higher temperatures are anticipated under most climate change scenarios. According to the 5th Assessment Report of the Intergovernmental Panel Climate Change, temperatures are expected to rise approximately five to eight degrees Fahrenheit by the end of this century, with the greatest warming to occur during the winter season. This warming trend may lead to shorter winters and a longer season for summer activities (Joyce *et al.*, 2001). As temperatures rise in the warmer desert areas and lower elevations of the forest, recreation demand may shift, increasing the demand for cooler temperatures in the higher elevations. For example, the Payson and Pleasant Valley Ranger districts may experience an increase in recreational off-highway vehicle use during summer months due to climate change.

Increasing Temperatures Related to Tropospheric Ozone

Higher temperatures are well correlated with high ozone levels. Scientific studies have shown that climate change could favor the formation of more ozone pollution in some areas, including the southwest. This effect may already be evident in Arizona, as summertime ozone levels tend to be higher in summer.

Ground-level ozone pollution is a significant health risk, especially for children with asthma (EPA, 2015) and according to the FLAG 2010 by the National Park Service, ozone is generally acknowledged as the air pollutant causing the greatest amount of injury and damage to vegetation. Because ozone levels are already high for western areas of the forest, increasing temperatures will likely increase ozone production leading to negative health effects, particularly for children who suffer from asthma.

According to EPA, evidence from observational studies strongly indicates that higher daily ozone concentrations are associated with increased asthma attacks, increased hospital admissions, increased daily mortality, and other markers of morbidity.

Worsening Drought Related to Dust

Semi-arid regions like the southwestern U.S. that are already prone to blowing dust, which have already been said to cause numerous air quality violations, may experience more of the same under worsening drought conditions due to climate change.

Increasing the aridity of soil makes it more prone to wind erosion during monsoon thunderstorms. High winds from thunderstorm outflows during the Arizona monsoon season cause blowing dust from crustal and otherwise desert surfaces that have been disturbed by past and present human activities. Even under the high winds produced by monsoonal thunderstorms, undisturbed desert surfaces do not emit dust at levels that would cause concern for national air quality standards. Thus, air quality can be improved through management actions such as the prohibition of cross-country travel as proposed in Alternatives B, C, and D, which eliminate cross-country travel entirely.

According to EPA, exposure to ambient PM_{10} particles is linked to a variety of health problems, including hospital admissions for heart disease, hospital admissions, and doctors' visits for respiratory diseases, increased respiratory symptoms in children, and premature death in people with heart or lung disease. Further highlighting the negative effects from PM_{10}, vehicle accidents, and valley fever serve as examples of the importance of reducing cross country travel on forest roads. In comparison with other planning objectives, a prohibition of cross-country travel would likely result in greatest benefit with respect to attainment of the 24-hour national ambient air quality standards (NAAQS) and ultimately to human health.

Effects to Climate Change

Agency direction defines the emission of greenhouse gases and effects to carbon cycling as the direct climate change effects of a project. The interaction of emissions with atmospheric concentrations of greenhouse gasses such that they impact the climate is defined as the potential indirect climate change effect (U.S. Forest Service, 2009).

Under this definition, there is no direct effect associated with any of the proposed actions considered in any of the alternatives. These alternatives do not authorize the emission of greenhouse gasses; the action alternatives do not limit the emission of greenhouse gasses; the action alternatives are unlikely to change carbon cycling or the emission of greenhouse gasses as compared to the no action alternative.

Regarding indirect effects, Agency direction states, "Because greenhouse gases mix readily into the global pool of greenhouse gases, it is not currently possible to ascertain the indirect effects of emissions from single or multiple sources (projects). Also, because the large majority of Forest Service projects are extremely small in the global atmospheric CO_2 context, it is not presently possible to conduct

quantitative analysis of actual climate change effects based on individual projects" (U.S. Forest Service, 2009, p. 4).

Based on this guidance, Alternatives B, C, and D do not have measurable indirect effects as compared with the No Action Alternative (Alternative A).

Effects of Climate Change

We are unable to predict differences in motorized vehicle use between the alternatives. It is possible that a smaller motorized route system will result in reduced motor vehicle use on the forest. It is also possible however that a similar number of users will be concentrated on a smaller network of motorized routes if Alternative B or C is selected and there will be no net change in motor vehicle emissions. It may also be that a smaller number of motorized route miles on the forest will simply shift users to locations off the forest and the net effect on greenhouse gas emissions would be unchanged. In the absence of this knowledge it is not possible to compare differences in greenhouse gas emissions between alternatives.

Alternative A

This alternative has more miles of motorized routes than any of the alternatives. It also permits the greatest area of off-road vehicle use for firewood gathering, motorized big game retrieval, dispersed camping and general off road vehicle use of any of the alternatives. Increased intensity of storm events expected from climate change would increase erosion and sedimentation from exposed road surfaces. The large number of stream crossings in this alternative reduces the resilience of channels and riparian areas to resist the erosive effects of floods. The larger mileage of roads in this alternative also provide a greater number of pathways for nonnative species to be introduced to native ecosystems which are more susceptible to non- native species due to stress from warmer temperatures and reduced water availability.

Alternative B

This alternative would designate more miles of motorized routes for decommissioning than any of the other alternatives. This alternative also results in the smallest area of off road disturbance of any of the alternatives for activities such as motorized dispersed camping, fuelwood gathering, and motorized big game retrieval. Reduced mileage of motorized routes open to cross country travel reduces erosion potential from high intensity storms. The reduced number of stream crossings improves stability of channels and aquatic habitat and provides greater resilience for channel and riparian areas from the flooding. Reduced mileage of roads reduces pathways for introducing non-native species to climate change stressed ecosystems. Cumulatively these effects result in greater landscape level resilience to climate change. Eventual revegetation of decommissioned routes may provide negligible sequestration of carbon.

Alternative C

Impacts would be intermediate between Alternatives A and B. This alternative would designate fewer miles of roads for decommissioning than Alternative B but more than Alternatives A and D. This alternative would reduce the area open to off road travel for motorized dispersed camping, firewood gathering, and motorized big game retrieval from that open in Alternatives A and D but would leave more area open for these activities than in Alternative B.

Alternative D

Impacts would be greater than Alternatives B and C but less than Alternative A due to designating even fewer miles of roads for decommissioning than in Alternatives B and C, and permitting off road motorized travel in larger areas for motorized big game retrieval, firewood gathering, dispersed camping and general off road motorized travel in designated OHV areas. Impacts would be less than Alternative A.

Cumulative Effects

The cumulative effects analysis evaluates past, present, and reasonably foreseeable actions effect on climate change within the boundary of the Tonto National Forest.

Wildfire risks increase as dry areas become dryer. Warmer average temperatures intensify the effects of drought, which may increase the intensity and severity of uncontrolled forest fires. These fires, in turn, pose a great threat to both local and regional air quality. According to IPCC 2007 and Seager, *et al*. 2007, the Southwestern U.S. is experiencing a drying trend that will continue well into the latter part of 21st century. Therefore, the prospect of higher temperatures and more intense drought conditions is of major concern for air quality managers.

Livestock grazing, forest restoration projects, construction projects, and fuels management activities along with various other recreational activities that occur on the Forest may or may not affect climate by altering the abundance or type of carbon-sequestering vegetation available on the landscape (Brown *et al*., 1997; Asner *et al.*, 2004; Archer and Predick, 2008) or by increasing dust. Industrial mining activities and outflow from major metropolitan areas, such as Phoenix, are other major sources of pollution with an additive effect on air quality on the Tonto National Forest.

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